PATENT SPECIFICATION

626,530

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(Under Section 6 (1) (a) of the Patents &c. (Emergency) Act, 1939, the proviso to Section 91 (4) of the Patents and Designs Acts, 1907 to 1946 became operative on June 26, 1946).

Index at acceptance:—**Classes 87(ii),** A1r42; **and 97(i),** J7(c: x).

COMPLETE SPECIFICATION

Improvements in or relating to Optical Systems comprising an Element for Correcting the Spherical Aberration of the System

We, N. V. PHILIPS' GLOEILAMPENFABRIEKEN, a limited liability Company, organized and established under the laws of the Kingdom of the Netherlands, having our seat and Office at Emmasingel 29, Eindhoven, Holland, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to optical systems comprising an optical element for correcting the spherical aberration of the system and to optical correcting elements when used in such systems.

It has been suggested to make lenses, particularly spectacle-glasses, of polysterol. It has, however, been found that although the use of this material and also of other materials which are capable of being moulded or of being treated in a similar manner for constituting lenses offers advantages in view of the low cost of manufacture, lenses made of this kind of material are comparatively inaccurate and are in addition without the required rigidity. It has now been found that the latter drawback can be removed comparatively simply by means which also create a possibility of meeting the first-mentioned difficulty.

According to the invention an optical system comprises an element for correcting the spherical aberration of the system, the correcting element having a non-spherical surface and being made of a transparent material which itself or the starting material from which it is manufactured is deformable at a low temperature, one surface of the correcting element being secured to a surface of an inorganic layer provided in the system. The term starting material is to be understood to mean the material from which the element is produced. With the use for example of a thermo-plastic synthetic resin, the starting material may be in powder form. The inorganic layer whose composition may be chosen according to circumstances serves as a support for the layer or layers constituting the correcting element which mainly derives its mechanical strength from the inorganic layer. The term "low temperature" is to be understood to mean a temperature of 300° C. or lower.

To constitute the correcting element use may be made of certain artificial materials, certain synthetic resins and certain natural resins. As examples of artificial substances we may mention, for example, certain benzyl-cellulose mouldable materials, pheno-plastics, amino-plastics and similar materials. In addition use may be made of a nitrocellulose mouldable material such as the product known under the trade name "Trolyte F" and in addition some synthetic forms of lacquer may be employed as the artificial material.

As synthetic resins we may mention *inter alia* polymerised vinyl compounds such as polysterol, mixed polymers, certain castable resins for example castable phenol resins, metacrylic acid esters or the like. In addition, transparent artificial rubber may be used successfully. As natural resins natural rubber (latex), japans, copal and dammar lacquers may be used *inter alia*. Depending on the nature of the material the correcting element may be shaped into the desired form by moulding, die-casting, extrusion, or a similar process. Some of these materials are thermo-plastic; an element part made of such material, after being

shaped into its final form, can be rendered plastic again by heating so that both the material of the correcting element and its starting material are capable of being deformed at a low temperature. In the case of other material, however, for example with certain synthetic resins, such physical and/or chemical change of the material occurs that the correcting element is not capable of being deformed at a low temperature but the starting material is.

The correcting element may alternatively consist of a material which has been gelatinised from solution and dried as described and claimed in British Patent Specification No. 19382/46, (Serial No. 614,255). Gelatinisable substance is to be intended to mean a substance capable of being colloidally distributed in the dissolved state and of being separated from this solution to form a gel. The term "gel" is intended to refer to such a solid substance possessed of rigidity accompanied by resilience.

Substances suitable for the purpose and capable of being gelatinised in the dissolved state may contain organic constituents such as gelatine, agar-agar and pectin. It is also possible for these substances to contain inorganic components such as silicates or alumina, either with or without glycerine, in order to improve the optical homogeneity of the correcting element. Depending on the substance, the solvent is chosen so as to obtain a gelatinisable solution. Water for example is chosen as a solvent of gelatine.

If desired, the correcting element may be hardened for example by means of formalin during or subsequent to drying.

The use of such a gelatinisable substance offers the advantage that due to the contraction that occurs during the drying of the gel, the matrix or templet into which the gelatinisable solution is introduced may have substantially larger dimensions than the correcting element to be manufactured with the aid of the said templet. This contraction may have a value of the order of magnitude of between 3 and 50. By imparting a given value to the concentration of the gelatinisable substance it is possible accurately to predetermine how much the contraction will be in a given case. If for example the contraction factor is chosen to be 8 a correcting element made from a gelatinisable substance and having differences in thickness at different parts of the correcting element of 0.3 mm. can be made in a templet in which the differences in level at different parts of the templet to produce the said differences in thickness is 2.4 mms. The templet can therefore be made very accurately on an enlarged scale with respect to the product and this provides an advantage.

It has been stated above that the correcting element mainly derives its mechanical strength from the inorganic layer to which this correcting element is secured and the correcting element can be constructed to be very thin. If the correcting element has a thickness at its thinnest parts which is less than $\frac{1}{30\text{th}}$ of its largest diameter the advantage is obtained that, the correcting element being very thin, there is no risk that large differences in thickness in the element part may lead to inhomogeneities thereof.

The optical system according to the invention lends itself particularly for use as a high quality system, for example, in opera glasses, cameras, projectors, spectographs, microscopes and similar instruments. Such is particularly the case when different parts of the optical correcting element contained in the system are small, for example smaller than 2 mms. The great accuracy which occurs with these small differences in thickness may be due to the fact that practically no inhomogeneities occur in the correcting element.

The manufacture of non-spherical surfaces in glass is comparatively costly since such surfaces are of necessity practically always ground by hand. This disadvantage can be obviated by constructing the correcting element concerned in the manner indicated above. In this case the non-spherical refracting surface may be made as a thin layer by moulding die-casting or extruding the material capable of being deformed at a low temperature or else by gelatinising and drying, and if desired hardening, from a solution. In this case such a correcting element may be applied to a plane or spherical inorganic plate, for example a glass plate. This inorganic layer or plate can therefore be shaped into the desired form by mechanical grinding and need not be subjected to an involved manual grinding process.

Naturally, such a correcting element may be secured to each side of a glass plate or lens.

The inorganic layer may be planoparallel. This construction offers particular advantages when the correcting element is very thin, the inorganic layer serving in this case almost entirely as a support.

It has been found that the optical

system according to the invention offers particular advantages when used in a Schmidt optical system as is described in the "Zentralzeitung für Mechanik und Optik," 52nd volume, 1931, page 25, in which an element for correcting the spherical aberration occurring with a concave mirror is provided in the system. In this kind of system it is known to give the desired correcting action to an originally plane glass plate by grinding the surface. Such a grinding process is however costly since the differences in thickness occurring between different parts of the glass correcting plate are very small and generally only of the order of magnitude of a few tenths of a millimeter. Since in such a case the correction element serves to exercise a correcting action it will exhibit practically no optical power in the paraxial region. With the use of an optical system according to the invention, a plano-parallel glass plate may be used and have secured to it a correcting element which for example may be moulded in a die or formed in a templet from a gelatinisable substance. In this case the die may be used for the manufacture of any number of correction elements.

It is preferable that in such an optical system that side of the correcting element which is remote from the inorganic layer to which this correcting element is secured should be protected by a further element of the system, which may be for example a lens, a mirror, or a glass plate. In an objective, such a correcting element may be applied, for example, to one of the objective flanges in such manner that the correcting element is protected by the lens to which it is applied and/or by the other lenses from contact or damage.

The correcting element is preferably made in such manner that it is applied to the inorganic layer by means of a die by moulding, die-casting, extrusion or a similar process. In some cases, the correcting element will adhere to the substratum spontaneously and in other cases use will be made of a suitable adhesive.

If the correcting element is made from a gelatinisable substance, a templet of suitable dimensions is preferably mounted above the inorganic layer which acts as a substratum and the gelatinisable substance which is in the dissolved state is introduced therein. The gelatinisable substance being gelatinised and dried, there is provided on the inorganic substratum a correcting element of the desired dimensions constituted by the gelatinised substance which, due to the shape of the templet and the degree of contraction, exhibits the desired shape. Since this correcting element adheres to the substratum during its formation, the contracting effect described is only obtained in the direction of the optical axis of the correcting element.

In order that the invention may be more clearly understood and readily carried into effect it will now be described more fully with reference to the accompanying drawing.

Figure 1 shows a construction of an optical correcting element in which a glass plate 3 constructed to be spherical on one side has applied to it a transparent layer 4 moulded from a benzyl cellulose material. The latter, which serves to exercise a correction on the action of the lens 3, has on its side remote from the glass a non-spherical surface with rotational symmetry which can be moulded from the benzyl cellulose material by simple means. The construction shown avoids the need for the glass surface itself to be ground to give the correcting form illustrated which is rather involved for a grinding operation.

Figure 2 shows an objective constituted by three lenses 5, 6 and 7 mounted in a metal sleeve 8. The lens 5 has secured to it a correcting element 9 made of polysterol. Due to the presence of the lenses 5, 6 and 7 and of the sleeve 8 the element 9 is protected from being damaged or touched under normal conditions. For the sake of clearness the dimensions of the correcting element 9 in the direction of the optical axis of the objective are shown enlarged.

Figures 3 and 4 show a construction of the correcting element in which a plano-parallel glass layer 10 has applied to it a non-spherical body 11 with rotational symmetry made of a substance capable of being gelatinised in the dissolved state. The glass layer 10 in this case acts as a substratum for a correcting element 11 to be used in a Schmidt optical system. Such an element may be made in the manner shown in Figure 3, the glass layer 10 serving as a substratum and being surmounted by a templet 12 which is hollow. The internal space in the templet is provided with two pipes 13 and 14 for the supply and discharge of water by which the templet is maintained at the desired temperature. In addition, the templet has formed in it a central bore 15 which serves as a supply pipe for the material 16 of which the body 11 is to be made. This may consist, for example, of water in which gelatine is dissolved in a given concentration corresponding to the desired contraction. By the water which flows through it the templet 12 is maintained at a temperature at which the gelatine just remains in the dissolved state. By

gradually reducing the temperature of the templet (if required of the glass plate also) the solution 16 is gelatinised and a gel is produced which is possessed of resilience accompanied by rigidity. The templet 12 can then be removed and the gelatinised material 16 remains on the plate 11. When this material is dried it contracts in a vertical direction so that the upper surface of the material 11 which by now is of pure gelatine is given the form indicated by the dotted line 17. At the same time this material of the correcting element has adhered to the plate 11 so that practically no contraction occurs in a horizontal direction. Finally the edge of the gelatine material is severed along the lines 18 and 19 and the gelatine may be hardened, if desired for example with the aid of formalin.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An optical system comprising an element for correcting the spherical aberration of the system, the correcting element having a non-spherical surface and being made of a transparent material which itself or the starting material from which it is manufactured is deformable at a low temperature, one surface of the correcting element being secured to a surface of an inorganic layer provided in the system.

2. A system as claimed in Claim 1 in which the surface of the correcting element remote from the inorganic layer is protected by a further element of the system.

3. A Schmidt optical system comprising an optical system as claimed in Claim 1 or 2.

4. In an optical system as claimed in Claim 1, an optical correcting element substantially as described with reference to Figure 1, Figure 2 or Figures 3 and 4 of the accompanying drawing.

Dated this 25th day of June, 1946.

T. D. THREADGOLD,
Chartered Patent Agent,
Century House, Shaftesbury Avenue,
London, W.C.2,
Agent for the Applicants.

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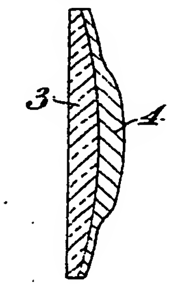
[This Drawing is a reproduction of the Original on a reduced scale.]

Fig.1.



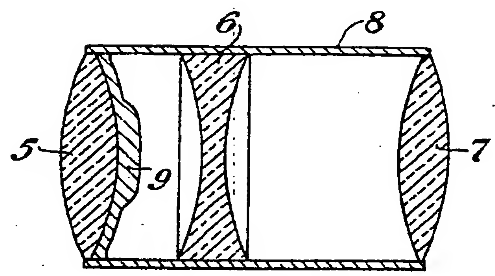


Fig.2.

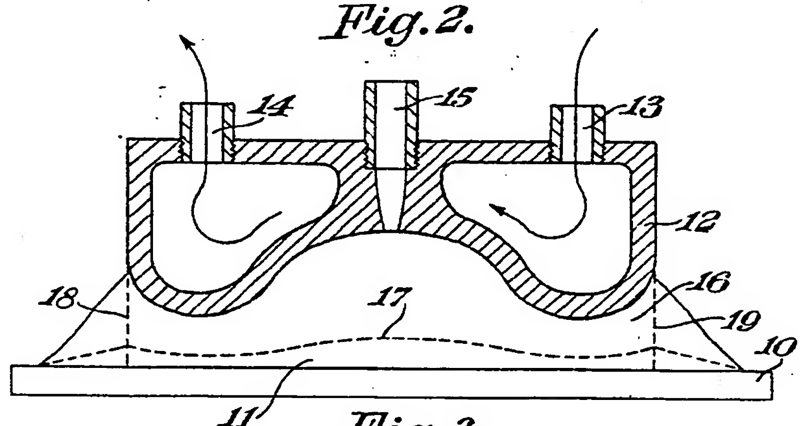


Fig.3.

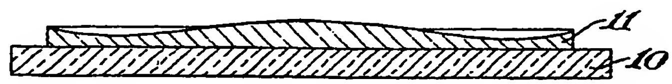


Fig.4.